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Financing for sustainability: Empirical analysis of green bond premium and issuer heterogeneity

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Abstract
More recently, investors' preference for green bonds is of particular interest for researchers. The possible non-pecuniary motive in sustainable finance can be identified by the green bond premium. But no consensus has been achieved owing to differences in samples and market settings. This paper specifically focuses on the estimation of the green bond premium in China. We introduced three issuance motivation theories to explain the drivers of green premium and convinced them through a set of empirical tests. The propensity score matching method was employed to claim that compared with matched conventional bonds, green bonds are priced at an average negative premium of 7.8bps, implying that green projects may be issued at a lower cost. Considering that a financial group has a higher negative premium than a corporate group, green financing for sustainable development is still led by indirect finance. Furthermore, empirical results convince that a negative premium is pronounced for state-owned enterprises and varies across the financial and corporate groups. Central SOEs have more advantage in raising funds than local SOEs. In addition, the effect of ownership on the green premium will significantly change if bond issues with a third-party verification. The role of verification is important in reducing information asymmetry and avoiding greenwashing behavior. We suggest that financial resources need to be properly allocated to the real enterprises through third-party verification or government supportive measures.

Keywords Green bond premium · Issuance motivation · Propensity score matching · Issuer heterogeneity · Third-party verification

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1 Introduction

The rapid growth of the green bond market has resulted in considerable research on the financial motives to invest in environment friendly assets, such as assets carrying lower risk weights (Kruger 2015) or those associated with better financial performance (Bauer and Hann 2014.). Moreover, companies with good environmental performance benefit from lower financing costs (Barclays 2015; Flammer 2018). Notably, the financial system of China differs from those of Europe and the US in terms of market structure: the Chinese financial system is characterized by a less developed bond market and a huge green investment gap. However, the high savings rates of citizens in China can effectively satisfy a large retail investor demand for green finance products. Therefore, investors' preference for green bonds and issuers' characteristics is of particular interest for researchers and policymakers.

Most findings have indicated that the green bond premium, specified as the issue spread between a green bond and a matched conventional bond, can identify the non-pecuniary motive to invest in the bond market (Zerbib 2019; Maria Jua Bachelet 2019). Few studies in the previous literature have revealed that the issue spread of green bond significantly differs in the primary market (HSBC 2016; Ehlers and Packer 2017).

Karpf and Mandel (2018) examined the yields of 1880 US municipal bonds and suggested a positive premium in the secondary market between 2010 and 2016. Malcolm Baker (2018) claimed a negative premium of 7 bps in their finding. Zerbib (2019) emphasized a moderate negative green premium for the financial group by using a two-step OLS procedure from 2013 to 2017. Explaining the premium puzzle, Maria Jua Bachelet (2019) reported that green bonds exhibit higher yields and lower volatility, instead are more liquid. Furthermore, the findings highlighted the importance of green third-party verifications in reducing information asymmetries.

Recently findings confirmed that green bond premium generally exist in emerging market. To check the correlation between the cost of debt financing and green bond issuance, a synthetic conventional bonds have been constructed to match each green bond (Wang, J et al. 2020).

To sum up, no consensus has been achieved owing to differences in samples and market settings. The existing literature fails to clearly identify the green bond premium in a transitional country with an underdeveloped financial market. This paper addresses two key aims as follows: (1) Are green bonds priced differently from matched counterparts in the Chinese bond market? Do they entail lower raising costs compared with matched bonds? (2) What are the determinants of green bond premium? The study contributions help estimate the green label effect in the Chinese bond market, propose the issuance motivation theory, highlight the effect of issuer ownership on green bond premium through a consistent set of empirical tests, and indicate that verification is essential in this emerging market.

This article is organized as follows. Section 2 provides the theoretical analysis in the field of green issuance motivation. Section 3 estimates the green bond premium using the propensity score matching (PSM) method and tests the matching quality. Section 4 examines the relation between property rights and green bond premium and discusses issuer heterogeneity as well as the significance of third-party verification. Section 5 concludes the paper.

2 Theoretical analysis and research hypothesis

2.1 Issuance motivation theory

The rapid growth of the green bond market has attracted a considerable amount of literature on the existence of green premium. Findings concerning the green premium have been diverse in terms of methodology, data sampling, or identification of determinants of green premium, thereby leading to general ambiguity. Furthermore, mixed results exist concerning the effect of issuer types of green bond on pricing premium when compared with the results concerning ordinary bond. Bonds issued by sovereigns, municipals, financial institutions, and corporates vary in terms of liquidity, credit risk, and target investors—the main drivers of the green bond premium (Malcolm Baker 2018; Zerbib 2019). Accordingly, understanding the issuers' motivation and issue characteristics will help address this controversy.

The three rationale motivations are as follows: (1) According to the signaling hypothesis, issuing bonds labeled 'green' is a credible signal of a company's commitment to undertaking green projects and improving their environmental performance (Lyon and Montgomery 2015; Flammer 2018). (2) The cheap financial cost hypothesis states that green bonds may entail lower financing costs if investors with non-pecuniary preferences would like to pay a green pricing premium, that is, accept lower financial returns in exchange for receiving pecuniary benefits (Flammer 2018). (3) The theory of greenwashing motivation claims that companies issue green bonds seemly to figure themselves as environmental-friendly, rather than to take concrete actions (Pearson 2010; Lyon and Montgomery 2015).

3 Research hypothesis

In emerging markets such as China, climate and environment-related risks have increased the need for green finance, particularly in the fields of transportation infrastructure, renewable energy and carbon emission reduction of traditional fossil energy companies. Most state-owned enterprises (SOEs) in these aforementioned domains have included corporate social responsibility as well as environmental, social, and governance (ESG) objectives. Furthermore, these enterprises have focused on issuing green bonds to signal their commitment toward undertaking green projects. Consequently, it is in companies' best interests to decrease asymmetric information to attract a pro-environment investor and engage in socially responsible investment. Evidence indicates that an improved ESG performance increases financial access.

Consequently, we propose the following hypothesis:

Hypothesis 1. Issuers with state-owned property rights may have more pronounced negative green bond premium than private groups.

Few studies have highlighted that green bonds entail lower financing costs. We observe that financial bond issuance constitutes a large proportion in the overall labeled Chinese green bond issuance. The proceeds issued by financial institutions are indirectly invested in green projects, offering green credit to support environmental-friendly projects. In general,

financial companies do not have an incentive to greenwashing but have a strong motivation to decrease their raising cost of capital for supporting more green credit asset.

Considering the heterogeneity of issue spread between the financial and corporate groups of SOEs, we propose the following:

Hypothesis 2 Compared with corporate groups, financial SOEs possess more negative green premium owing to lower credit risk and high rating reputation.

Some findings have highlighted the significance of green third-party certification in eliminating greenwashing motivation, resulting in a relatively more convenient financing condition (Maria Jua Bachelet et al.2019).

Accordingly, we propose the following hypothesis:

Hypothesis 3 Green third-party certification moderates the relationship between non-SOEs' issuer type and green premium similar to that of corporate groups.

4 Estimation of the green bond premium

4.1 Data source and summary statistics

Our sample includes all bonds issued on the Shanghai and Shenzhen stock exchanges and interbank bond market from 2016 to 2018 but excludes all issuers with missing data.

Some empirical challenges exist in this paper. First, the identification standards of green projects are not completely consistent owing to the different types of bonds under the supervision of the National Development and Reform Commission (NDRC) and the People's Bank of China (PBC). Until 2019, the NDRC and other seven departments jointly issued the Green Industry Guidance Catalog, the country's first clear green industry standards, to clarify the industry boundary. This paper defines green bond whose proceeds are raised for a pro-environmentally purpose. To be more specific, bonds specified as 'green' in our paper must meet the requirements in the guidance documents issued by the NDRC, CBRC, and PBC (Table 1).

When we estimate a green premium, specified as the issue spread between a green bond and a matched ordinary bond, to identify the effect of investors' green preferences, we observe that Chinese corporates or institutions seldom issue green and ordinary bonds in

Table 1 Definition of variables

Variables	Definition
Green premium	Spread of issue rate for green bonds and matched conventional bond
Irate	Issue rate
Amount	Issuance size
Rating	Bond rating
Maturity	Years to maturity
SOEs	Dummy variable, 1 represents bonds issued by the sate-owned enterprise and 0 otherwise
Verified	Dummy variable, 1 represents bonds that have been verified by a third-party and 0 otherwise

the same year. This means that we cannot employ the simple matching method to construct a counterfactual from the same issuer when maturity, credit rating, financial risk, and other differences have been controlled (Zerbib 2019; Maria Jua Bachelet 2019). Thus, the PSM method is preferred for the estimation of green bond premium to reduce excessive dimensioning problems and identify a reasonable comparable counterpart.

We construct data samples from two major sources. The corporate data have been collected from the CSMAR Database, which contains information about listed companies' basic firm characteristics. The second major data pertain to third-party verification information by issuers who drive to promote transparency. The data have been manually collected from Xinhua Green Finance Database.

Our sample includes 418 green bonds and 1648 conventional non-green bonds used for matching. We will provide the estimation of green bond premium using the PSM method in this part. Further study will be conducted to empirically test the determinants of green bond premium in Sect. 4. Our research mainly focuses on the heterogeneity of issuer ownership. Description of variables in the following analysis is listed in Table1.

Table 2 presents the descriptive statistic of variables for green bond (treatment group) and non-green bonds (control group). A t-test examines the mean differences between these two groups. The last two columns indicate that green bonds issued by financial firms statistically differ from their conventional bond group in terms of issue rate. On the contrary, we were unable to find differences in issue rate in the corporate panel.

4.2 Premium of green bond versus non-green bonds

4.2.1 PSM matching result

We identify the effect of a bond labeled 'green' on its issue rate and compare it with that of the corresponding ordinary bond.

Table 2 Statistics of the sample (418 green bonds and 1648 conventional bonds)

Treatment	Green				Non-Green				*Diff*	
	Mean	Med	Min	Max	Mean	Med	Min	Max	Mean	P
Panel A. Financial										
Outcome variables										
Irate	4.49	4.48	2.94	6.5	4.73	4.8	2.89	7.0	− 0.24	0.007
Independent variables										
Amount	41.92	20.00	1.00	300.00	62.34	30.00	2.00	500.00	− 20.41	0.026
Rating	5.71	6.00	1.00	8.00	6.02	8.00	1.00	9.00	− 0.31	0.013
Maturity	3.32	3.00	2.00	5.00	4.86	3.00	0.47	15.00	− 1.53	0.000
Panel B. Corporate										
Outcome variables										
Irate	5.49	5.37	2.80	9.63	5.46	5.33	2.84	9.20	0.025	0.29
Independent variables										
Amount	8.16	5.00	0.07	50.00	13.52	10.00	0.50	127.00	− 5.36	0.00
Rating	6.71	8.00	1.00	8.00	6.19	6.00	1.00	8.00	0.518	0.00
Maturity	5.42	5.00	0.59	15.00	4.54	5.00	2.00	10.00	0.875	0.00

First, we use logit model to estimate the probability of a firm's issuance of a green bond to obtain propensity scores. Thereafter, we obtain comparable match pairs through propensity scores, which meet the requirement that the outcome variables need to be independent of treatment conditional on propensity scores. Before matching, a set of variables are chosen based on the economic theory and prior empirical literatures (Maria Jua Bachelet 2019). We choose a set of issuer characteristic variables such as issue amount, issuer type, and maturity as reasonable covariables according to our regression model.

Table 3 presents the average treatment effects for the green bond. We use the nearest neighbor matching method in Panel A: the differential issue rate between the two groups is − 0.37. When the radius and kernel matching algorithms are employed, the differential issue rates are − 0.31 and − 0.22, which are statistically significant.

These results indicate that the level of issue rate of the green bond is lower than that of the non-green bond after matching methods used to adjust the characteristic variables in financial group. The issue spread is caused by bonds' green label effect rather than bond characteristics. The findings also reveal that green premium significantly positively affects issue rate in the corporate panel, implying the absence of a green label effect for the corporate issuer. In other words, the results indicate higher raising cost for corporates in the green bond market.

Furthermore, the matching quality needs to be assessed. We use a two-sample t-test to verify if the covariate means between two groups significantly differ. Differences are expected before matching, but the covariates should be balanced after matching; accordingly, the distribution of *X*-variables remains the same in both groups. The test results before and after matching are estimated.

Table 4 presents the differences between treatment and control groups in mean. All covariates have substantially reduced after nearest neighbor matching, implying that the matches are effective and successful in narrowing the difference for both groups.

4.2.2 Estimation of green premium

Given the matched counterfactual bonds, we can estimate the premium using the issue rate spreads from 2016 to 2018. Let r_i^{GB} and r_i^{CB} be the offering yield of green bond and the

Table 3 Average treatment effect on the treated (ATT): Green label effect on Issue rate

	Nearest neighbor				Caliper and Radius				Kernel			
	T	C	Diff	SE	T	C	Diff	SE	T	C	Diff	SE
Panel A Financial												
Unmatched	4.49	4.72	− .23***	.08	4.49	4.72	− .23***	.08	4.49	4.72	− .23***	.08
ATT	4.49	4.86	− .37***	.16	4.48	4.80	− .31***	.09	4.49	4.71	− .22***	.08
Panel B Corporate												
Unmatched	5.48	5.46	.02**	.08	5.48	5.46	.03**	.08	5.48	5.46	.02**	.30
ATT	5.48	5.37	.11**	.14	5.33	5.50	.17**	.12	5.48	5.48	.01***	.03

k-nearest neighbor matching with k = 1, Radius matching with caliper 0.01, kernel matching with bandwidth 0.01 ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 4 Balance tests for NN matching

Variable	Sample	Financial				Corporate			
		Mean		*t-test*		Mean		*t-test*	
		Green	Non-Green	*t*	$p>t$	Green	Non-Green	*t*	$p>t$
Maturity	U	3.32	4.86	−4.89	0.00	5.36	4.54	7.01	0.00
	M	3.32	3.22	0.60	0.55	4.97	4.75	1.40	0.16
Issuer type	U	3.62	3.24	2.94	0.00	4.55	5.61	−7.31	0.00
	M	3.62	3.44	1.03	0.30	4.59	4.34	1.46	0.14
Amount	U	41.92	62.33	−2.22	0.01	8.41	13.52	−6.63	0.00
	M	41.92	41.31	0.07	0.94	8.52	9.15	−0.92	0.36

matched conventional bond at issuance in the primary market, respectively. We estimate the green premium using the following equation:

$$\Delta r_i = r_i^{GB} - r_i^{CB}$$

The summary statistics for the green bond premium are presented in Table 5. The average differential issue rate between green and non-green bonds was negative at around −7.8 bps for the entire sample. Especially, the green premium for the financial group was around −22.2 bp, lower than that of the corporate group.

The results suggest a huge advantage of green bond issuance for Chinese banking or other financial institutions in the capital market. By contrast, no significant negative result was observed in the corporate panel, implying that industrial companies were unable to acquire a cheap source of debt financing for green bond issuance.

These initial results explain why financial bond issuance constitutes a large proportion in the green bond market. They have great motivation to acquire a cheap cost of capital. It should be noted that the proceeds issued by financial institution are always offering green credit to support environmental-friendly projects. In other words, it is indirectly invested in green projects. Notably, we conclude that indirect finance plays a leading role in financing for sustainable development in China.

5 Drivers of the green bond premium

5.1 Regression results of property rights and green bond premium

We are interested in green bond characteristics which most generally show a green premium. In this paper, we mainly focus on the impact of issuer ownership on the

Table 5 Description of green premium in subsamples

Green premium	Obs.	Mean	SD	Min	Max
Panel A *Financial*	96	−0.222	0.638	−1.627	1.658
Panel B *Corporate*	322	0.003	1.222	3.002	4.024
Total	418	−0.078	1.150	−2.599	4.150

Table6 Effect of issuers' property rights on the green premium

Dependent variable: Green premium on offering yield				
Variables	(1)	(2)	(3)	(4)
SOEs	−0.879***	−0.589**	−1.053***	−0.573**
	(−6.00)	(−2.37)	(−6.94)	(−2.25)
FinancialXSOEs		−0.307***		
		(−3.2)		
CorporateXSOEs				−0.858***
				(-2.98)
Financial	−0.942***	−1.206***		
	(−7.84)	(−5.92)		
Corporate			0.130	0.574**
			(1.37)	(2.13)
Rating	−0.144***	−0.141***	−0.103***	−0.110***
	(−6.89)	(−6.59)	(−4.62)	(−4.95)
Amount	−0.005***	−0.005***	−0.008***	−0.008***
	(−4.61)	(−4.35)	(−5.35)	(−5.29)
Maturity	0.012	0.014	0.044	0.037
	(0.71)	(0.81)	(1.37)	(1.04)
Constant	2.475***	2.456***	2.192***	2.664***
	(11.63)	(11.44)	(9.48)	(10.93)
Year	Yes	Yes	Yes	Yes
Observations	418	418	418	418
R-squared	0.535	0.536	0.467	0.483

Robust t-statistics in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

green premium. To analyse the determinants of the green bond premium. 'SOEs' is a dummy variable for bonds issued by the sate-owned enterprises. Other variables such as issuer characteristics and bond information are controlled. Results in Table 6 indicate that when we control for maturity, rating, and issue amount, all specifications support the hypotheses that green bonds issued by SOEs have a higher negative premium than those issued by non-SOEs.

Further, we conduct some additional tests by considering issuer characteristics (its financial or corporate nature) to reduce asymmetric information. Considering that financial institutions exhibit different operating mechanisms, the results demonstrate that types of financial bonds significantly negatively affect the premium, contrary to those of corporate bonds. This result indicates that.

compared with industrial companies, financial institutions can issue green bonds at a lower financing premium. Green financing for sustainable development is still led by indirect finance. Columns (2) and (4) address the interaction effect of ownership and sector. Green bond issued by SOEs negatively affect the premium in any sector. Moreover, corporate group significantly negatively affects green premium unless it belongs to a SOE entity: the coefficient is −0.858.

5.2 Issuer heterogeneity analysis

Our empirical analysis in Table 6 indicates that the property right of issuer has a statistically significant effect on green bond premium. In this section, we verify the robustness of these results and demonstrate that they are quite stable across financial and non-financial institutions. Table 7 indicates that green bond premium would be affected by firm characteristics, e.g., type of ownership varies across financial and non-financial groups. Two types of SOEs exist in China: Central and local. Results suggest that central SOEs and local SOEs had a greater significant negative effect on financial bond premium compared with the corporate group. Furthermore, the result indicates that central SOEs have higher effect on green bond premium than local SOEs regardless of the group. The estimated coefficients dropped from -0.5 bp to -0.95 bp, indicating that central SOEs have more advantage in lower raising cost when issuing green bond than local SOEs group.

5.3 Is third-party verification effective?

How can the issuer assure that the proceeds are used for the 'green' purpose? Is there any third-party monitoring and verification to ensure that the purpose of the green bond has been met? An external third-party verification is often introduced to exhibit the issuer's capability to implement the program as well as theoretically avoid the risk of adverse selection and greenwashing behavior.

This part investigates whether third-party certification significantly affects offering yields. Table 8 presents that green bonds verified by a third-party significantly negatively affects green bond premium.

In the first and third specifications, the issuer types with corporate and non-SOEs have positive coefficient when similar characteristics and timing are controlled, indicating that these two kinds of issuers have higher raising cost than their correspondents.

How to acquire the same advantage as the SOEs or financial institution? An implication of our findings is that third-party verifications reduce informational asymmetries and generate relatively more favorable raising conditions. Results reveal that the coefficient on cross interaction effects is strongly significantly negative when third-party certification is included. Overall, corporate and non-SOEs benefit from the third-party verification.

Table 7 Issuer heterogeneity analysis

	Dependent variable: Green premium	
	Financial	Corporate
SOE_central	−1.345***	−0.955***
	(−4.34)	(−3.60)
SOE_local	−1.096***	−0.500*
	(−3.75)	(−1.95)
Issuer type	Yes	Yes
Year	Yes	Yes
R-squared	0.522	0.574

Robust *t*-statistics in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 8 Estimation of verification on green premium

Dependent variable: Green premium				
Variables	(1)	(2)	(3)	(4)
Verified	−0.555**	−0.598**	−0.758***	-0.602*
	(−2.54)	(−2.46)	(−5.71)	(1.90)
Corporate	0.307*	0.615**		
	(1.96)	(2.52)		
CorporateXVerified		−0.346***		
		(3.12)		
Non-SOE			0.899***	0.0831*
			(2.89)	(1.76)
Non-SOEXVerified				−1.510***
				(−2.62)
Rating	−0.168***	−0.172***	−0.144***	−0.140***
	(−4.76)	(−4.70)	(−4.76)	(−4.91)
Amount	−0.007***	−0.006***	−0.007***	−0.007***
	(−3.74)	(−3.68)	(−3.79)	(−3.78)
Constant	1.711***	1.482***	1.960***	0.654
	(4.07)	(5.15)	(6.80)	(1.08)
Observations	251	251	251	251
R-squared	0.312	0.314	0.352	0.385

Robust t-statistics in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

6 Conclusions

This paper mainly focused on the differential issue rate between green bond and a matched conventional bond. The possible pre-environmental preference in sustainable finance can be identified by the green premium. Using the PSM method, we provide the evidence that green bonds are indeed issued at a negative premium compared with the conventional bonds. Estimation indicates that financial institutions would face a favorable resourcing environment compared with corporate groups. Furthermore, empirical results suggest that state-owned ownership significantly affects green premium and varies across financial and non-financial sectors. SOE firms, such as central SOEs, and local SOEs, have advantage in raising funds for green projects. We highlight that the effect of ownership on the premium will be significantly changed if a green bond is verified by a third-party. The role of verification and information disclosure is important in reducing financing cost for private corporates. The findings of the research help us to better understand both the investors' green preference and the issuers' motivations. We suggest that market funds need to be properly allocated to the real enterprises through third-party verification or government supportive policies.

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Compliance with ethical standards

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